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Challenges in developing modular services in manufacturing companies: A multiple case study in Danish manufacturing industry

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Abstract

Customers are increasingly expecting customized and personalized physical products and service offerings to fit their unique needs. To manage these diverse customer needs, applying modularity is relevant. Modularity in product design is a widespread and well-established research field while research on service modularity is still rather immature. Research on service modularity mainly relates to the service industry and only limited research exists on service modularity in manufacturing industry. Based on case studies in industry, this paper examines challenges when developing modular services in a product-service-system context. The study concludes that several challenges exist, such as lacking foundation for service control.

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Keywords: servitization; product-service system; PSS; modularity; modularization; service modularity; Denmark; danish manufacturing industry; multiple case study msslmsslmss

1. Introduction

Globalization has implied that market competition has increased beyond national borders which caused an increased competition [1, 2]. Therefore, competitive parameters beyond price and product have captured the attention of manufacturers to stand stronger in the global competition [1, 3], particularly in high-wage countries. Adding services to the value proposition and thereby extending it from providing products to providing product-service systems (PSS) [1, 4] accounts for one of these parameters, as services are more difficult to imitate compared to physical products. This creates an opportunity for the manufacturer to establish lasting differentiation from competitors.[5] The strategic transition from producing and selling products to also include the sales and production of services in a manufacturing company is also known as servitization [1, 5]. However, the transition towards integrating services implies an increase in internal complexity [6-9] in

terms of e.g. data management, control of service systems, and management of relations between products and services.

Equivalent to products, service customization and service variety often gradually increase in manufacturing companies either due to growth initiatives or to create a competitive advantage in the market. Therefore, the number of variants often grows unexpectedly, if no underlying structures to support the management and control of these service variants are in place.

The market is increasingly demanding offerings customized to their personal needs [10] for which reason it is expected that manufacturers should be able to manage even higher levels of product variety in the future and thus also higher levels of service customization and variety than today. Adding services to the value proposition while at the same time trying to customize the PSS to customer preferences thus implies a further increase in internal complexity [6, 7, 9, 11] in regard to e.g. management of service variants and service production,

both of which manufacturers must be able to manage. Therefore, to manage this complexity without compromising the opportunity to customize the offering to the customer, a mass customization strategy approach is highly relevant [6, 12].

In a modular architecture, standard modules with standardized interfaces can be combined to customize the offering to fit the customer's personal needs [10]. Consequently, modularity is a well-known approach in mass customization and has previously been used in design of e.g. products [12, 13] and production systems [14, 15] to reduce complexity without compromising the opportunity to customize the solution provided to the customer [6, 12]. More recently, research on modularity has extended to services [12] and PSS modularity [13, 16]. However, research on PSS modularity is particularly scarce although considered relevant for further studies [12, 13, 16].

As stated by Brax et al. [12] and Iman [17], no common definition for service modularity exists. However, service modularity may be explained as activities which are part of interactions between components in a service system [17]. PSS modularity covers both products and services but differs from product and service modularity, respectively, due to the interrelations between products and services in the PSS. PSS modularity therefore needs to account for these interrelations for which reason existing research related to product or service modularity individually, cannot be applied.[16] Research on service modularity in manufacturing industry is relevant due to manufacturers' limited experience in service management and because manufacturing companies have historically been organized around the production of products, which may to some extent conflict with the organization of service provision. The transition towards becoming a servitization company is challenging for many companies and the process of becoming a servitizer is still a rather unexplored research field.[5] Customizing and modularizing the offering in addition to this further challenges the implementation of a servitization strategy. For this reason, it is relevant to study the challenges related to developing and implementing modular services in manufacturing industry further and thereby be able to account for these in future research to ensure successful application in industry. This study investigates the challenges related to modularizing services in servitization companies through a multiple case study.

The structure of the remaining part of the paper is as follows. Section 2 presents a literature review on development methodologies of modular services in PSS. In section 3, the applied methodology for data collection is presented together with a short description of the two case companies. The findings of the case studies are presented in section 4 followed by a discussion of the findings in section 5. Lastly, the conclusion of the research paper is presented in section 6.

2. Literature review

Given that research on PSS modularity and customization is limited [9, 12, 16, 18], a multiple case study is conducted to further explore challenges to developing and implementing modular services in manufacturing industry. However, to

support the case study methodology this section presents a brief review on state-of-the-art literature on development methodologies for modular services in manufacturing industry and thereby the process towards reaching an operable solution. The investigated challenges are those, which may complicate the development process and in worst case prevent service modularity from being applied in industry. For this reason, it is considered necessary to explore the required development steps before presenting the case study findings.

Ezzat et al. [6] present a four-step methodology for developing modular PSS: 1) the company's existing products and services are identified and defined in a structure suitable for the company's offerings, 2) relations between two services, two products, and a product and a service are evaluated by using a design structure matrix (DSM), 3) the results of the DSM are clustered to form modules, 4) the performance of the modules are evaluated. The proposed methodology by Ezzat et al. [6] does not provide definite analyses to be used in the individual steps, as opposed to Song and Sakao [18] who also provide a four step methodology while proposing several analyses to accompany the steps for developing modular services in PSS. Song and Sakao [18] propose the following steps: 1) identify and analyze requirements for the PSS, 2) translate requirements into technical attributes, and evaluate and solve possible conflicts between the attributes, 3) identify components and cluster them into modules, and 4) compose a configuration model. Another comprehensive methodology for developing modular services in PSS is proposed by Li et al. [19] and contains five steps which are supported by related analyses: 1) determine service needs and structure these through a classification, 2) find a principal solution for each need, 3) determine the preliminary modular structure based on the principal solution, 4) combine solutions for each service need into a PSS solution, and 5) evaluate the PSS solutions to determine optimal solutions.

Larsen et al. [16] identified four main steps in state-of-the-art literature on development methodologies for modular services in PSS. The four steps are: 1) identify customer requirements, 2) translate customer requirements into service specifications, 3) construct service modules, and 4) setup configuration model. Where Ezzat et al. [6] primarily focus on constructing the modules, corresponding to step three, both Song and Sakao [18], and Li et al. [19] propose comprehensive development methodologies which reflect all of the four identified steps by Larsen et al. [16].

Currently, research on development methodologies for modular services in PSS focuses on developing parts of a solution (see e.g. [20–22]) and thus does not hold a systems view, which means that relations and synergies might be disregarded, and complexity might be overlooked. Concepts proposed in literature furthermore tend to be developed from a theoretical point of view whereupon they are validated in a case study (see e.g. [20–24]). Since industry insight is not incorporated into the proposed development methodologies, applicability in industry may be questioned considering the natural complexity faced in industrial settings and missing insight into challenges and differences in developing modular services in manufacturing companies. When the applicability in industry is questioned, the opportunity to translate research

results into market value is doubtful. Since industry challenges are thereby not incorporated into research results, it is problematic that research focusing on exploring industry context in relation to developing modular services in PSS is scarce. Therefore, to ensure applicability in industry the contextual understanding of the research field should be studied further.

In regard to developing modular services in manufacturing industry, research on challenges in industry related to this is of interest in an attempt to accommodate these in future research and thereby improve the applicability of future research results. Therefore, this case study seeks to contribute to the research field with contextual understanding of industrial challenges, that is aspects which complicate the development of modular services in manufacturing companies. As a result of this the following research question has been addressed: *Which challenges related to developing modular services in manufacturing companies can be observed in industry?* The empirical foundation for answering the research question is based on two case studies from Danish industry. The research question is answered throughout sections 4 and 5.

3. Methodology

According to Creswell [25] a qualitative research approach is suitable for exploring topics with unknown variables and theory base. As only limited knowledge on challenges related to developing modular services in manufacturing companies exists, a qualitative research approach is used to answer the research question by conducting two case studies. According to Voss et al. [26], observing actual practice through case studies contributes with valuable insight to the subject being studied. In addition to this, case studies are relevant to apply in exploratory settings, where many factors are still unknown and new theory needs to be developed [26, 27]. The cases included in the case study were selected based on their similarities to conduct a replication study and thereby predict similar results whereby findings can be generalized beyond the subjects being studied.[26, 27]

The cases are two large Danish manufacturers who are both international suppliers in the business-to-business segment. Case A employs approximately 550 employees and generates an annual turnover of around €850 million. Case B employs around 400 employees and generates an annual turnover of approximately €215 million. Case A supplies farmers, and produces and sells simple products whereas case B provides cooling solutions which are products with higher complexity. Both companies have grown significantly in recent years, and services are vital for the companies' existence. Whereas the interest for services in case B is highly driven by customer demand, services in case A are besides customer requests also driven by an internal request from the case company to grow organically. Common to both cases is the internal focus on developing and controlling services is limited in both companies. The differences in the motivation for developing the companies' service systems may affect the findings. However, the case findings are considered comparable since both companies have the same starting point for developing the service system.

The two cases were part of two separate research projects extending beyond the purpose of this paper. The research projects focused on conducting feasibility studies of modular services in a PSS context. Both projects were performed by the authors of this paper. In case A, case specific information for the feasibility study was collected through eight semi-structured interviews over a four-months period. To study the research question from several hierarchical levels in the organization the interviewees were selected based on their knowledge of the company's services and their representation of different organizational control levels. Therefore, top managers, middle managers and employees from operations were interviewed. In case B, seven semi-structured interviews were conducted over a three-months period and used in the case study. Like in case A, the interviewees were selected based on their knowledge of services and representation of different control levels in the organization. The interviewees were therefore top managers, middle managers and employees from operations. In addition to interviews, data from internal presentations, archival data, corporate websites and the internal intranet from both case companies were collected and used to study the research question.

As presented in section 2, state-of-the-art literature includes four steps for developing modular services in PSS. The feasibility studies took offset in these four steps. Based on the feasibility study findings, the challenges, which complicated the execution of the four steps, are presented in this paper.

4. Case study findings

As mentioned, the case study findings are presented according to the four-step methodology identified by Larsen et al. [16] which reflects the main steps in state-of-the-art research on development methodologies for modular services in PSS. Therefore, it is relevant to take an offset in these four steps when exploring the propounded research question.

The identified challenges in developing modular services in PSS for both cases are presented in Table 1. Out of a total of 20 identified challenges, 18 challenges were present in both cases.

As addressed in section 3, the cases are operating in two different industries with different levels of product complexity. The findings, however, reflect that the challenges which the companies face are similar despite their diverse business characteristics. This highly supports the generalizability of the findings for which reason it is expected that manufacturing companies in similar contexts are exposed to similar challenges. Both companies are currently working on creating internal structures and systems to support their customized service offerings and thus creating a robustness to support future growth. Therefore, the findings may not be generalizable to companies that have already created supporting structures and systems for their services.

5. Discussion and future research directions

In this section the findings from the case study presented in Table 1 are further elaborated and discussed based on the four

development steps which the challenges have been identified in accordance with. Additionally, future research directions are presented.

5.1. Identify customer requirements

As shown in Table 1 nine of the identified challenges are related to the first step. Prior to the research projects, the companies' attention to their service systems and the management thereof were highly limited, despite services being a key differentiating factor for both companies. Consequently, working with the companies' services was complicated by several issues. The companies for instance did not have an overview of the content of their service portfolio and the relations between products and services were unknown. The findings indicate that limited attention to the service system causes significant challenges to the development of modular services in manufacturing companies. Furthermore, collecting and structuring input data for modularizing services appear to be challenging which indicates that future research should study how to manage the data input and prepare the organization for working with services.

5.2. Translate customer requirements into service specifications

The second step is challenged by various types of communication challenges. A challenge often mentioned in literature regarding services is that they are intangible [28, 29] and thus lack tangible attributes which can be used to describe the service and the expectations of the customer to the service [28]. This indicates that communication about services is challenging in general. This is also the case in both case companies. The employees are not used to addressing services like they address products, and the production and operation of products which also means that they do not share a common frame of reference. This indicates that to improve the communication about services and align the employees' perception of the content in the service portfolio, the companies would benefit from a framework for developing modular services which can support the development process and thus the companies' common understanding of services. Furthermore, such framework may also support the collection and structuring of input data as pointed out in section 5.1. Future research may therefore study frameworks, and specific tools and methods to develop modular services and thus assist

Table 1. Challenges identified in case studies based on the four steps for developing modular services in PSS.

Development steps from Larsen et. al [16]	Identified challenges in the case companies	Case A	Case B
1) Identify customer requirements	Development of the company's service system is controlled by customers' demand instead of internal management decisions		x
	Does not have an internal foundation and structure which supports and controls the services provided to customers	x	x
	Content of the company's current service portfolio is not defined	x	x
	Relations between products and services in PSS have not been identified and formalized	x	x
	Does not have enough insight to make an economic justification of whether or not to develop a modular service system to support the future control of the company's service system	x	x
	Dependency on employees' tacit knowledge on services because this knowledge has not been written down and thereby made accessible for all members of the organization	x	x
	Missing opportunity for knowledge sharing with similar companies on how to develop a modular service system and implement it with success		x
	Services are provided free of charge which means that data registration of provided services is limited	x	x
	Little recognition of services as a strategic asset and thereby lack of acknowledgement that focus on the company's service system is of high importance	x	x
2) Translate customer requirements into service specifications	Silo control in organizational structure which challenges the operations of services across departments	x	x
	Do not share the same frame of reference for services as a result of not having defined the content of the company's service portfolio	x	x
	Communication on services is challenged because the company is not used to explicitly talking about services and the control of them	x	x
	Services are intangible which implies that the perception of the content of one service can be different from one employee to another	x	x
3) Construct service modules	Lack of tools and methods to construct service modules	x	x
	Employees do not have competencies in service control and development	x	x
	Missing internal experience with developing and controlling service systems	x	x
4) Setup configuration model	Development of new working structures which support the company's services	x	x
	Handling of new service variants when demanded by customers is done ad-hoc instead of following a standard procedure for developing new variants	x	x
	Change of organization culture from manufacturer of products to manufacturer of products and services	x	x
	Difficulty in making an economic assessment of configured customized service solution	x	x

to accommodate the challenging task of service communication.

5.3. Construct service modules

The challenges related to designing the service modules in step three indicate that companies do not have the resources to construct a modular service system. The case companies both lack tools and methods to support the process as well as competencies and experience in developing a service system. The findings of Larsen et al. [16] indicate that the applicability in industry of service modularity in manufacturing companies is limited which again indicates that other companies besides the case companies are experiencing similar challenges. Future research may therefore study tools and methods that support the construction of modular services systems in industry.

5.4. Setup configuration model

The challenges in the last step are related to taking service modularity into operation in manufacturing companies. The cases have no prior experience with managing a service system and a service culture in a manufacturing company context. Hence it is not surprising that the companies experience challenges in the transition which requires organizing new working structures for services, setting up procedures for managing demand of new services, and changing the organization culture. To support manufacturing companies in this transition, future research may therefore, examine the implementation and operation of modular service systems in manufacturing companies.

Another challenge identified in step four is to assess the economic value of a configured customized service solution and thereby the possibility to determine the cost of providing the customized service to the customer. Determining costs of services is more difficult compared to products since services are intangible and thus for instance do not have bill of materials to support the cost calculations. If companies do not have an appropriate cost model for determining service prices the company risks either losing money if the price is too low, or losing customers if the price is too high. Therefore, to support the companies' cost calculations future research may look into cost modelling in modular service systems.

6. Conclusion

The market is increasingly demanding customized offerings. Simultaneously, manufacturing companies are transitioning into becoming servitization companies by extending their offerings to the customers from products to PSS. Customizing and extending the offering to the customer implies an increase in internal complexity as well. Consequently, to manage the complexity related to offering customized services, service modularity may be applied. However, research on service modularity in servitization companies is very scarce, and research on developing modular services lacks insight from industry. Therefore, this paper examined challenges related to developing modular services in manufacturing companies. The findings were found based on four main steps identified in

state-of-the-art research on developing modular services in PSS. Challenges like establishing relations between products and services in PSS, economic justification of implementing service modularity, service communication, and handling of new service variants were identified. Several challenges were related to the first step, identifying customer requirements, which were primarily a result of limited attention to service system management prior to the case study. Challenges related to step two, translating customer requirements into service specifications, were primarily related to communication whereas step three, constructing service modules, was challenged by limited research on tools and methods to support the development of modular services in manufacturing companies. Finally, the challenges related to step four, setup configuration model, were mainly linked to using modular services in the daily operations. Despite the two case companies' diverse business characteristics the faced challenges are alike for which reason the findings are expected to be generalizable beyond the two cases being studied. To support the development of modular services in manufacturing companies, future research may focus on studying tools and methods for collecting input data, supporting service communication and modular service development, and examining cost modelling of customized service solutions.

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